SMALL SPACECRAFT TECHNOLOGY PLAN
2020 SBIR INNOVATION & OPPORTUNITY CONFERENCE

EXPLORE SMALL SPACECRAFT

SMALL, RAPID, AFFORDABLE & TRANSFORMATIVE

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WHY ARE WE (VIRTUALLY) HERE

- NASA believes small spacecraft have the potential to shape how the agency approaches what is possible
- Achieving these desired future states (“Outcomes”) will likely leverage rapid development and costs below those of traditional missions
- There is no single technical solution – many Technology Gaps have been identified and realizing these Outcomes will require combinations of innovations
- Closing the identified Technology Gaps will move us towards achieving the desired Outcomes
- NASA is currently developing a priority order to those Technology Gaps so that resources can be invested strategically on solutions that have:
    - The highest “Architectural” applicability to stakeholders within NASA and small spacecraft community
    - The largest impact on achieving the desired Outcomes
- NASA will fund these priorities through future STMD funding opportunities, including SBIR subtopics

STMD SMALL SPACECRAFT TECHNOLOGY CAPABILITY AREA

NASA is pursuing rapid identification, development, and testing of capabilities that exploit ***agile spacecraft platforms and responsive launch*** capabilities to increase the pace of space exploration, scientific discovery, and the expansion of space commerce.

These emerging capabilities have the potential to enable new mission architectures, enhance conventional missions, and promote development and deployment on faster timelines. This will, in turn, allow NASA to achieve its objectives at significantly lower programmatic risk and cost than traditional approaches.

The plan is largely focused on technology gaps for ***CubeSats and microsatellites*** that use standardized form factors, interchangeable commercial components, and can be batch produced.

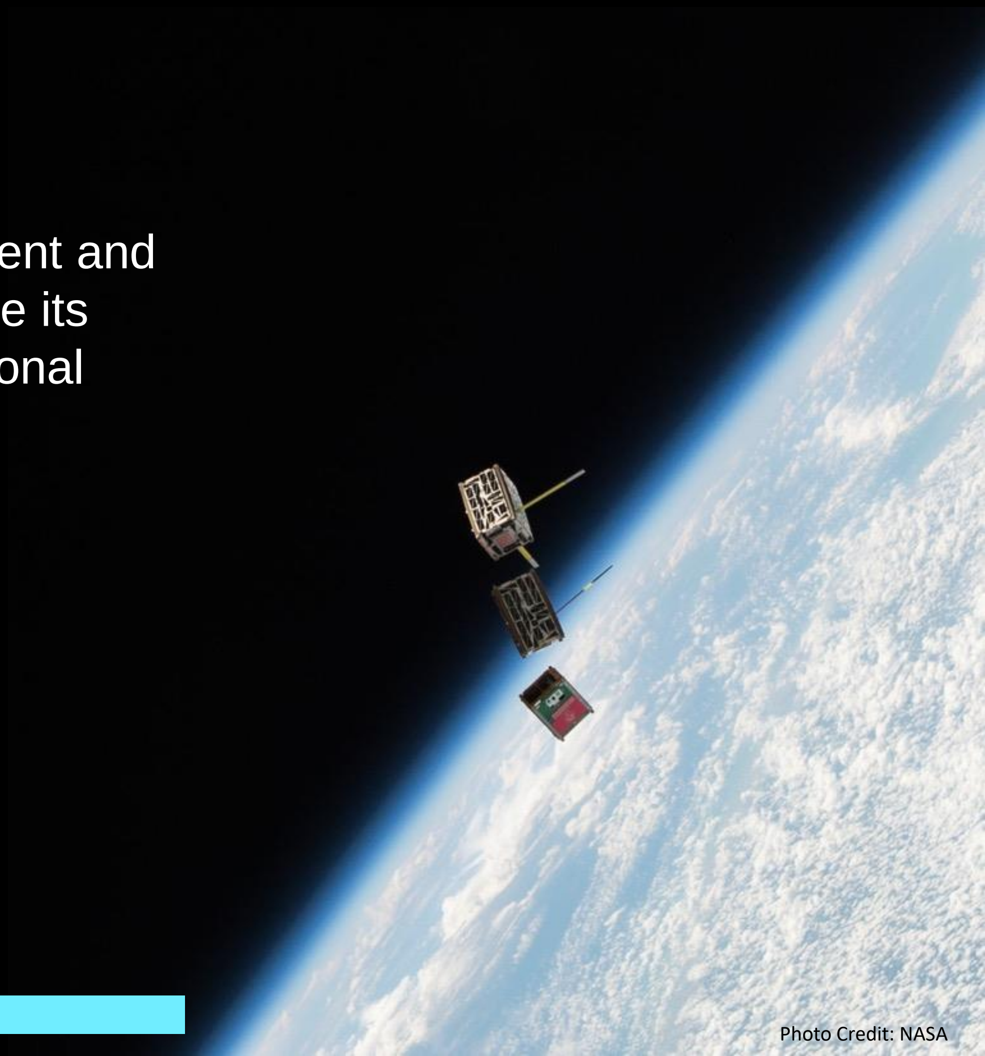

Photo Credit: NASA

BASED ON DRAFT PLAN · SUBJECT TO CHANGE

STMD SMALL SPACECRAFT TECHNOLOGY ARCHITECTURAL APPLICABILITY

MOON to MARS

Exploration Architectures for Human Lunar Return, Sustained Human Presence, & First Human Mars Expedition

Small spacecraft afford an increasingly capable platform to precede and accompany human explorers to the Moon, Mars, and other destinations to scout terrain, characterize the environment, identify risks, and prospect for resources. Distributed systems of small spacecraft can responsively provide cost-effective communications, monitoring, and inspection infrastructure for human exploration missions and cislunar commercial activity.

SOLAR SYSTEM & BEYOND

Scientific Discovery Architectures for Earth, Planetary, Heliophysics, & Astrophysics

The affordability and speed of small spacecraft allows more missions to more destinations of scientific interest. Additionally, the use of small spacecraft as affordable distributed systems can enable new science measurements in deep space and around planetary bodies that are not attainable using traditional approaches

SPACE TECH

Technology Demonstration, Commercial, and National Security Architectures

NASA’s overarching technology goals for its engagement in the small spacecraft ecosystem are to enable rapid and more affordable missions for exploration and discovery while facilitating the expansion of space commerce.

DESIRED FUTURE STATES ("OUTCOMES") RELATED TO SMALL SPACECRAFT CAPABILITIES

GO "OUTCOMES"

- Affordable on demand access to the Moon, Mars, the rest of the inner planets, and other deep space destinations this side of the asteroid belt. (*Target: Under $15M with multiple opportunities per year.*)
- Access to the outer planets, their moons, and beyond for small missions.

EXPLORE "OUTCOMES"

- Small, rapid and affordable missions competitive with traditional systems for targeted measurements at the Moon, Mars, the rest of the inner planets, and the asteroid belt. (*Target: Under $30M, including launch, and developed in under 3 years.*)
- Affordable, modular, and interoperable communications, navigation, and support infrastructure with full coverage of the Moon and Mars. (*Target: Under $20M to build and deliver each network node.*)
- Affordable distributed missions of at least 30 to 100 networked spacecraft acting as a sensor web in deep space. (*Target: Under $10M to build and deliver each node.*)
- Affordable deep space capable distributed systems that can form multi-kilometer wide synthetic apertures and multi-kilometer long virtual telescopes. (*Target: Under $20M to build and deliver each element.*)
- Small spacecraft able to accompany and augment larger missions to the outer planets and their moons.

LEAD "OUTCOMES"

- Rapid in space test capabilities that allow a technology to move from laboratory to orbit in less than 9 months.

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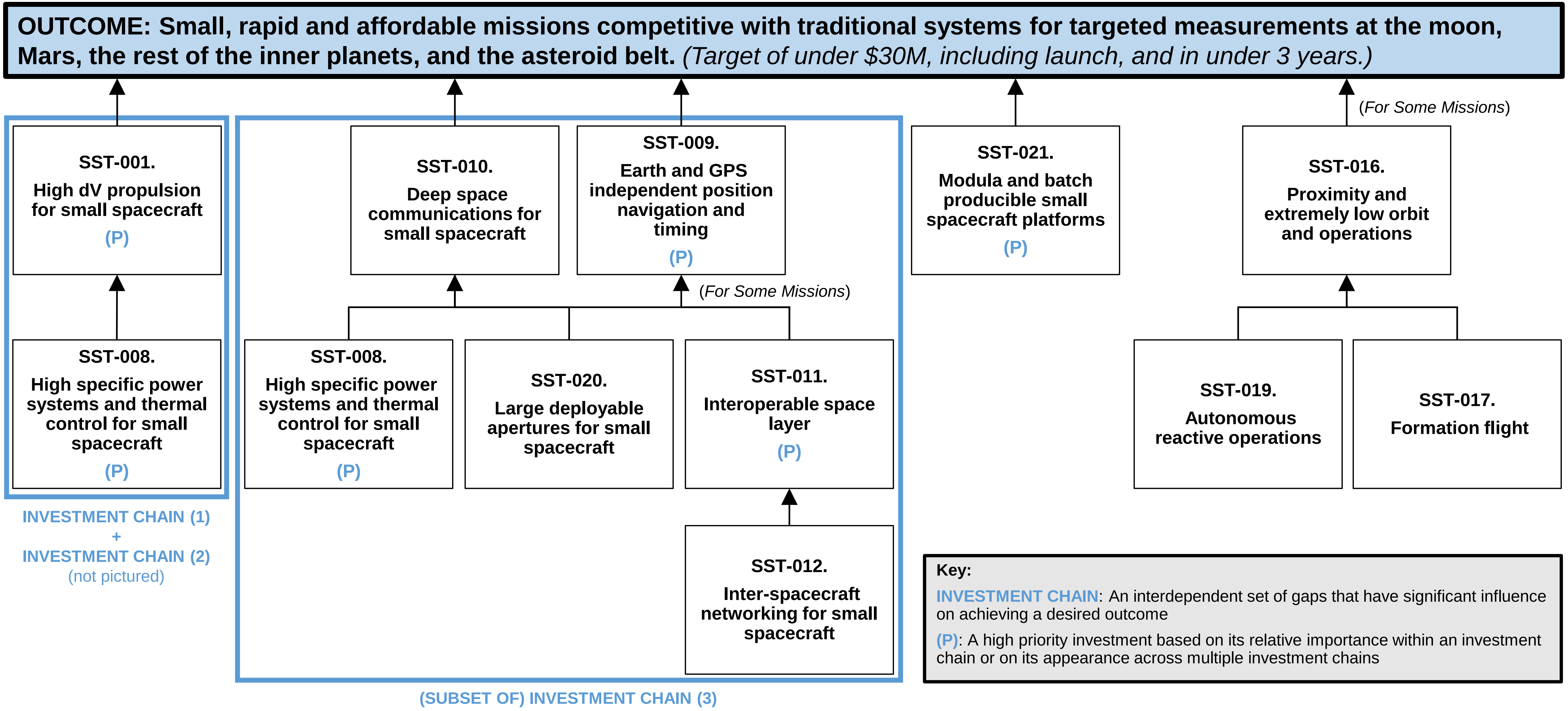
SELECT TECHNOLOGY DEVELOPMENT PATH EXAMPLE



SST-001. HIGH dV PROPULSION FOR SMALL SPACECRAFT (P)

Enabling many of the deep space missions envisioned for multiple classes of small spacecraft requires approximately 2 to 5 km/s dV over the multiyear life of a mission. To enable that level of propulsive capability in CubeSats, systems are required that have a high impulse per unit of spacecraft and high total impulse, while remaining low power per unit of spacecraft and compatible with secondary payload launch restrictions.

A FEW KEY ELEMENTS:

- At least 2 km/s dV
- High impulse per unit of spacecraft and high total impulse
- Low power per unit of spacecraft
- Compatible with secondary payload launch restrictions
- Tolerant to the deep space radiation and thermal environment over a multiyear mission
- For CubeSats use of high-density propellant may be needed to achieve the required performance within volume limitations.
- Microsatellite scale systems have relaxed size, weight, and power constraints but need increased thrust levels

SST-009. EARTH AND GPS INDEPENDENT POSITION NAVIGATION AND TIMING (P)

Further expansion of small spacecraft use into deep space requires highly accurate position knowledge and precision timing that does not depend on GPS or other Earth centric aids. Future small spacecraft missions will need to autonomously determine and transmit relative and absolute position as well as keep and exchange precise timing. These capabilities are required for small spacecraft to act as infrastructure for other missions, for distributed missions comprised of small spacecraft, and for standalone small spacecraft missions beyond Earth.

A FEW KEY ELEMENTS:

- Navigation technologies and techniques may include inertial navigation combined with…
  - Enhanced visual navigation capabilities
    (Like dual use of star tracking instruments for relative navigation using surface features or other spacecraft)
  - X-ray emissions (from pulsars)
  - Laser range finding with other spacecraft or surface landmarks.
- Compatible with the inherent size, weight, power, and cost constraints of CubeSats & microsatellites.
- Onboard image and data processing is required to allow for autonomous navigation.
- Precise timekeeping and timing exchange is not only required for navigation but is fundamental to science data.

SST-021. MODULAR AND BATCH PRODUCIBLE SMALL SPACECRAFT PLATFORMS (P)

Interchangeable hardware and software with standardized interfaces enable spacecraft to be built up from “plug and play” components. This facilitates introduction of new capabilities and tailoring of spacecraft designs for novel applications without requiring significant modifications to commercial-off-the-shelf platforms. Modularity can be used to increase reliability and introduce unique functionality for deep space missions without sacrificing the ability to leverage innovations in the commercial sector. Partnership with industry on batch production of spacecraft will be required to fully realize the potential for distributed missions including synthetic apertures, disaggregated science observations, rapidly established planetary communications architectures, constellations, and sensor web applications.

A FEW KEY ELEMENTS:

- Standardization of subsystem interfaces can help enable unique mission configurations with COTS hardware

  (Expand the reach of small spacecraft to new destinations without losing the speed and agility that has made the platform highly successful in LEO)
- Extend standardization principles into larger microsatellites
- Affordable and adaptable methods of addressing radiation tolerance / thermal environment
- Reduce spacecraft manufacturing complexity
- Regular production of low-cost and shorter lead time (< 12 months) platforms that can be made deep space capable

HOW TO LEVERAGE THE SMALL SPACECRAFT TECHNOLOGY PLAN

- This plan is **still a draft** and subject to change…
- Goals of the plan include:
  - Clearly communicating NASA needs
  - Helping NASA prioritize future solicitations / investments on the technologies that are most impactful
  - Helping proposers identify where their technology development efforts algin with NASA priorities
- Full draft of Outcomes & Technology Gaps (presentation version) is attached for reference
- Small spacecraft community feedback on draft plan is desired
  - Targeting an RFI in early October

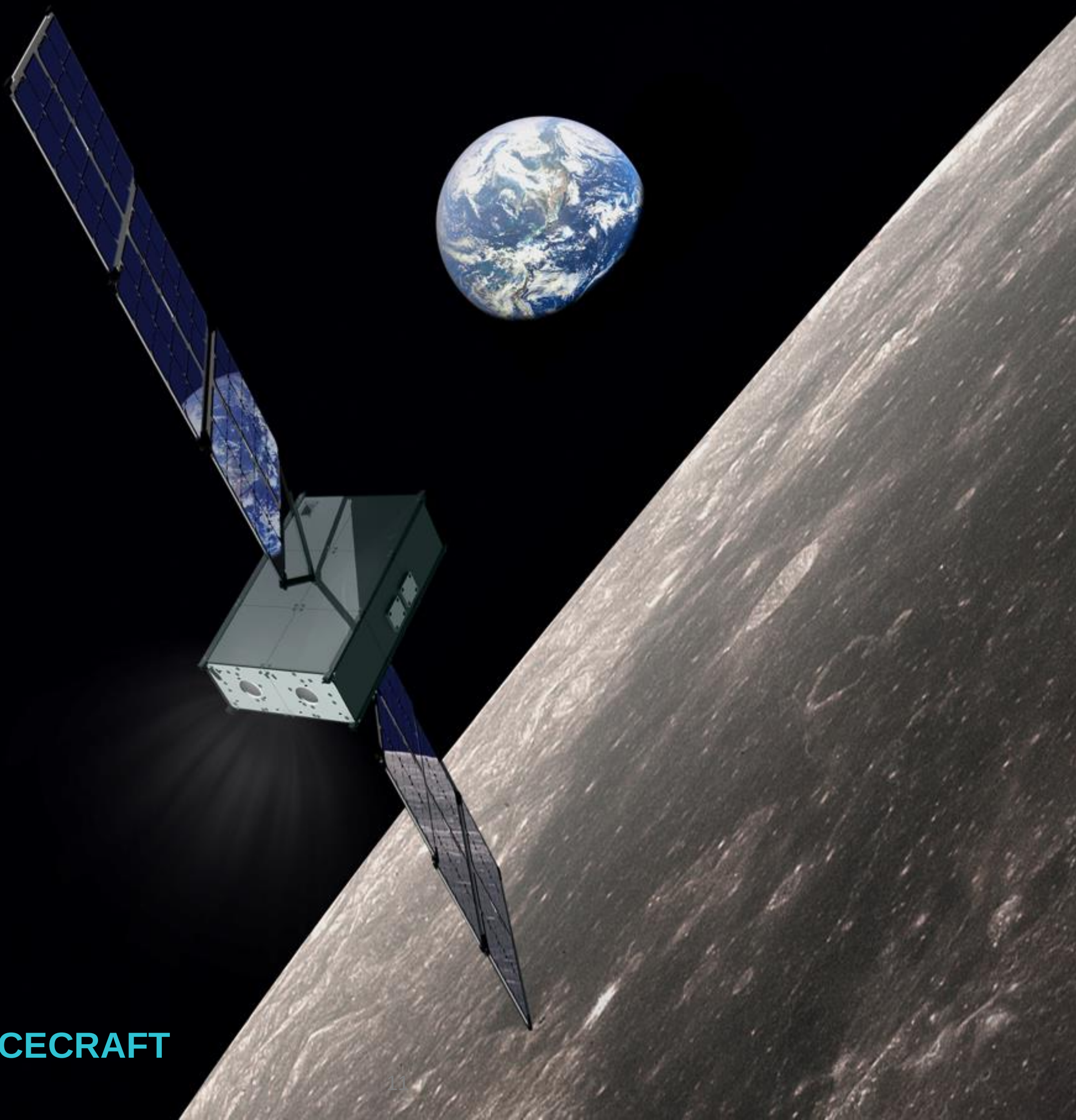
EXPLORE SPACE TECH

WITH SMALL SPACECRAFT

The Small Spacecraft Technology (SST) program expands the ability to execute unique missions through rapid development and demonstration of capabilities for small spacecraft applicable to exploration, science and the commercial space sector.

Notes for SBIR companies

- SST often leverages SBIR-developed technologies and brings them to flight
- SBIR companies should stay aware of the program’s activities and opportunities



LEARN MORE: **WWW.NASA.GOV/DIRECTORATES/SPACETECH/SMALL_SPACECRAFT**

EXPLORE SPACE TECH

THROUGH SUBORBITAL FLIGHT

The Flight Opportunities (FO) program facilitates rapid demonstration of promising technologies for space exploration, discovery, and the expansion of space commerce through suborbital testing with industry flight providers

Notes for SBIR companies

- Annual Tech Flights solicitation provides awards to fund suborbital flight tests with commercial providers
- Companies with a SBIR Phase I award are eligible to request FO facilitate suborbital testing via a Phase III
- FO can be an external investor in a Post Phase II activity that includes suborbital testing

LEARN MORE: WWW.NASA.GOV/DIRECTORATES/SPACETECH/FLIGHTOPPORTUNITIES

Photo Credit: Blue Origin

NASA